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14. ABSTRACT
Report developed under STTR contract for topic: AF03T022.

This report highlights the successful use of improved artificial intelligence (AI) within a detailed combat simulation software package, *Point of Attack 2*. The improved AI capabilities were applied to a wide range of functional areas, resulted in a much more flexible, and easy to use program, and also allowed users to better model unique force doctrines and reactions. It also improved the capabilities of the AI-controlled opponent, resulting in more challenging and enjoyable games for single human players, as well as increasing the applicability and potential uses of AI vs. AI experimentation. By allowing scenarios to play out without requiring any human input, large numbers of scenarios can be conveniently run at the same time, and the results statistically correlated to produce final analyses with high confidence levels.

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STTR report, computer based combat modeling and analysis, artificial intelligence (AI), software, PC.

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Adaptive Artificial Intelligence for Next-Generation Conflict Simulation
Phase I
Final Report

HPS Simulations

4 July 2004

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1. Summary

Point of Attack-2, originally developed under an AFOSR sponsored SBIR/STTR contract is one of the most detailed and configurable military combat simulation programs available. In terms of realism, scope, customizing options, and fidelity it far outstrips any civilian wargame, and rivals or even surpasses those now in official use by the US military. It is now being used for a variety of training and predictive missions, and as users become familiar with the program and its capabilities, the number and range of those uses should increase as well.

From that perspective, improving the program in terms of ease of use and producing more realistic results for AI-controlled forces, is something that can be expected to repay the investment in the modifications many times over.

The results of this Phase I project demonstrate that these improvements are feasible to accomplish within the scale of SBIR/STTR efforts, and that these types of modifications can have a major and positive impact on how the program is perceived by users, as well as the overall efficiency in both military and commercial usage.

2. Objectives

There were two primary objectives of the Phase I effort, both based upon using the existing wargame/simulation *Point of Attack 2*.

The first goal was to fully characterize an effective PC/Windows based software package that would incorporate improved and user-customizable AI routines into the models. The intent of these user-accessible routines was to better model standard force disposition and reaction characteristics, as well as some aspects of unique national characteristics.

A second and perhaps even more important objective was to evaluate the accessibility of the program within its intended military and commercial markets. Because of the simulation's extreme complexity and vast range of interface and command options, using it effectively can present users with a daunting challenge. This is especially true for new users, and/or those not yet familiar with the system or with weapons system capabilities and tactics. AI routines are essential in making the program manageable and allowing users to set up and execute scenarios to get the information and experience they want.

Once these initial steps were completed, the Phase I effort was to produce actual software to demonstrate both the feasibility of coding the improved AI routines and the potential gain within a number of test scenarios. While this evaluation software would contain only a limited number of user-editable AI values, it was intended to demonstrate how the changes could substantially increase the viability of the existing AI routines, as well as showcase the user interface for the AI.

Results from the evaluation software were be compared to previous versions of the game in order to judge how effective they have been, and how the improved AI adds to the overall experience of users.

3. Work Carried Out

The Phase I project work effort was carried out in two steps. In the first step, major functional areas were identified as being particularly well suited for further development – either because they were difficult for users, or because they were not efficient or effective. Based on this selection, potential methods were devised in order to effect the desired development, resulting in one or more algorithms or models. These were then researched in depth to determine the best course of action to achieve the desired outcome.

Once that particular model or algorithm was identified, it was coded into the program, and the results evaluated.

This process resulted in the following major upgrades and new options and items being added to the program:

- **Composite Units (New):** User-definable groups of sub-units that use AI to be handled as a single unit from the user's perspective.
  - Composite units are created at the start of a scenario automatically based on TO&E relationships.
  - Composite units have two local options: "Stay Together" and "AI Targeting Only". Both options use AI to make the units easier to control by human players.
  - Composite units may replace key weapons system losses by "re-manning" them from other sections. The AI makes the decision to re-man, as well as the determination of the composition of the replacement operators.
- **Movement Path Determination (Upgrade):** These AI routines determine the path a unit takes from point A to point B".
  - The efficacy was improved. Paths are now found if they exist at all, anywhere on the map, including the use of bridges and engineering-constructions.
  - The execution speed of the routines was improved.
- **Strategic AI (Upgrade):** These AI routines determine force objectives and force dispositions.
  - The responsiveness to changing situations and planning ability of the routines was improved for both human and computer players.
- **Formation Movement (Upgrade):** This powerful AI capability moves formations (of any size) with a single click (objective selection) by the player.
  - Formations maintain better and more realistic spacing, and HQ units are kept from moving until all subordinates have moved out.
  - Objective selection was improved based on the overall AI plan for the force.
  - Execution speed was improved by adding a timed break if a path was found.
- **Human AI Aggressiveness Level (New):** The aggressiveness level is used in determining the strategy, targeting, and movement decisions made by the AI for the human player's force. The aggressiveness levels and their general tendencies are:
  - **High:** Values quick movement, long range fire, and force concentration in single sectors.
  - **Medium:** Balances speed with cover, ammo expenditure with kill probabilities, and only allows for moderate force concentration.
  - **Low:** Values cover and concealment, waits for moderately high kill probabilities before opening fire, and evenly balances the force across all sectors.
- **Unit SOP (New/Upgrade):** Unit SOP's (standing operating procedures) determine how a unit will react in various circumstances in the absence of specific orders from the human player (i.e., under temporary AI control).
  - Targeting priorities.
  - Engagement ranges detailing when to open fire on targets, including limitations for ambushes.
  - Reactions to enemy fire: movement, return fire, and engagement priorities.
- **Combat Action Reporting (Upgrade):** These reports inform the user of what is occurring on the battlefield. There are 5 player-selectable levels of detail available.
  - Added the ability to print the results to a "running" file.
  - Added more information to reports at the highest detail level, including penetration and angle values, and secondary explosions.
  - Added additional information on airstrike aborts and unit morale changes.
- **Improved Combat Engineering Operations (Upgrade):** The interface was improved to use additional AI routines to make it easier for players to assign units to engineering missions, and to determine how long they are expected to take. Combat Engineering operations include:
  - Mobility: the construction/repair of bridges and road features, as well as the neutralization/creation of lanes through obstacles and minefields.
  - Counter-mobility: The construction of obstacles, laying of minefields, and the destruction of bridges and roads intended to impede the enemy's advance.
  - Survivability: the construction of fighting and improved positions that provide cover and concealment to friendly forces.

- **Scenario Creation (New/Upgrade):** The scenario creation process was made more comprehensive and flexible:
    - The process was made into a floating "checklist" form, allowing users and the AI to modify any aspect of the scenario at any time during the creation process.
    - Additional values were made available to the user to change, including LOS characteristics, the map to use, the expert level, and the AI aggressiveness and targeting values.
    - Existing scenarios can now also be modified as if they were newly created, including by the AI.

The changes are incorporated as version 2.02 of the program, which as of 3 July 2004 has been distributed to testers and users as a beta (in final testing) version. Once beta-testing is complete, version 2.02 will be offered as a general upgrade release.

4. Phase I Results

The AI work done in Phase I resulted in a much superior program in terms of ease of use, customizability, and execution time. They have also made the program much more enjoyable to use from a game standpoint.

This was demonstrated overwhelmingly in the reports received from testers and users who felt that the program was much smoother and faster in execution, more enjoyable and fun to play. Most also commented that the AI strategy was improved, and that units and forces were responding more accurately.

While these views are subjective, they nonetheless represent an important finding. Most of the testers are former military officers, and all are avid and knowledgeable wargamers familiar with modern military operations and modeling. Additionally, since enjoyment itself is a subjective, yet critical measure these results validate that the improvement objectives in this area have been achieved.

There are also measurable results. AI movement phase execution times have been reduced by an average of 60%, and the incidence of the AI being unable to find a movement path between two points has been eliminated completely. The AI now issues strategic orders to the force under its control three times as often as before, and the kill ratio for AI controlled forces in contact has more than doubled.

The time required for players to give orders to their force over the course of a scenario has been reduced by approximately half, and the scenarios themselves are being completed in less time, up to 60% less if the user is not using animations.

5. Technical Feasibility

Based on these results, it is apparent that it is feasible to make significant improvements to the program using the existing routines and knowledge base. Further, many these modifications can be in an incremental fashion, which allows for a great deal of flexibility in matching expected performance increases with the work effort required.

In addition to improvements to the existing basic models and routines of the program, this research has demonstrated that it is also feasible and desirable to construct an overall AI and force manager module. This module has been dubbed the "Chief of Staff", in that it will consolidate and monitor every aspect of the program for human players, and allow them to interact with the interface in plain language.

6. Personnel Involved

Scott S. Hamilton, Principle Investigator
Jeff Lapkoff, Programming
Greg Smith, Research, Database development
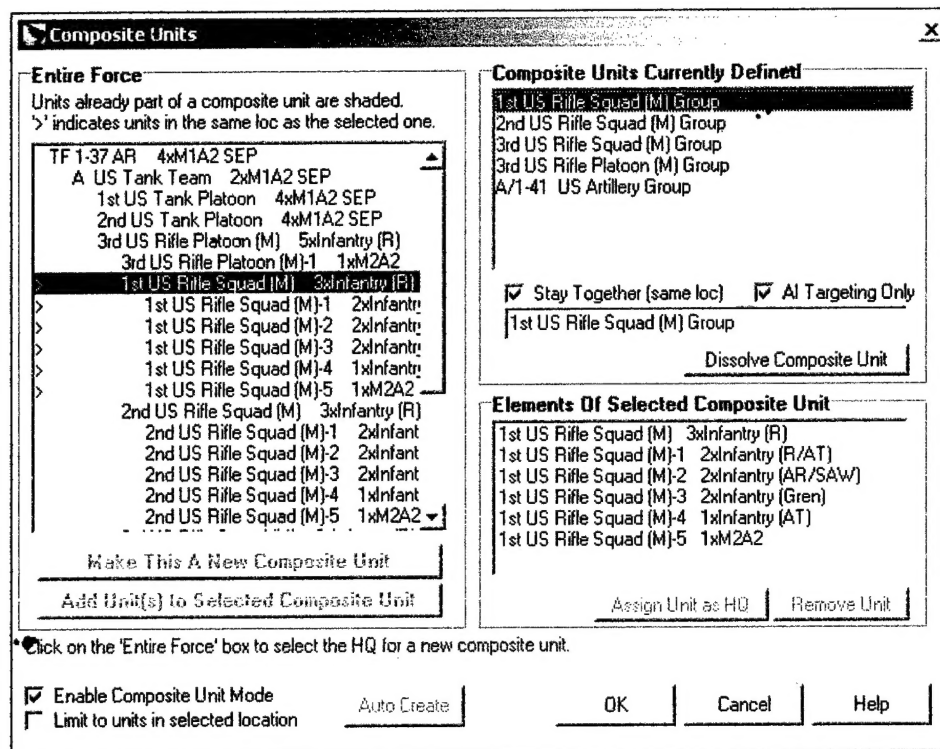Dr. Henry Lowood, Stanford University

Appendix A: Screen Shots

Figure 1: Composite Units. Multiple subunits are grouped into a single unit for ease of use, while retaining accurate weapons characteristics.
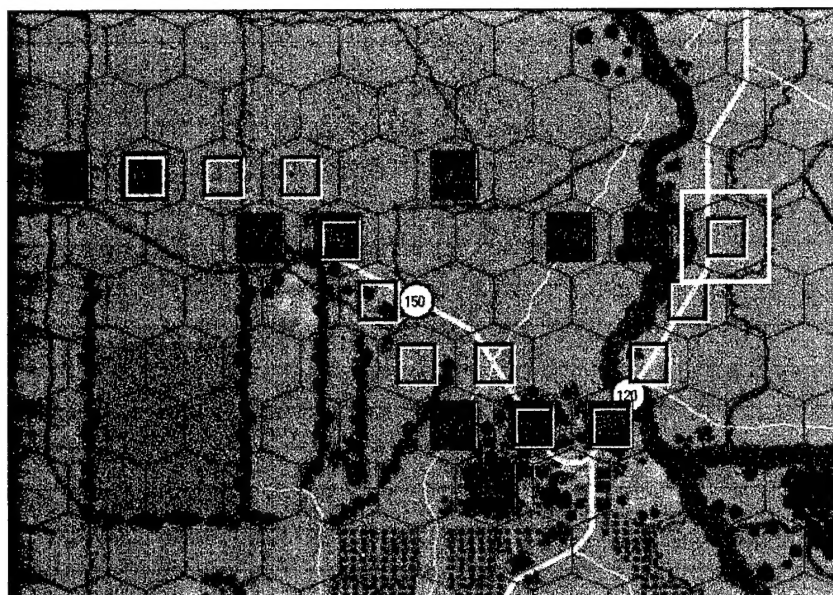

Figure 2: Movement Path. The AI has calculated a movement path (blue/yellow squares) across the river for the tank unit at that far left using the Class 120 bridge (yellow circle).
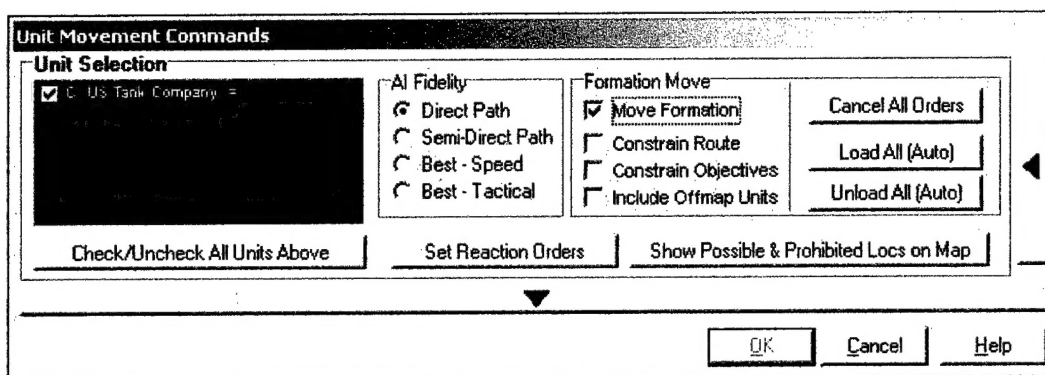
Figure 3: Formation Movement. This window allows users to move entire formations with one click. The AI routines can be adjusted using the radio buttons/check boxes.
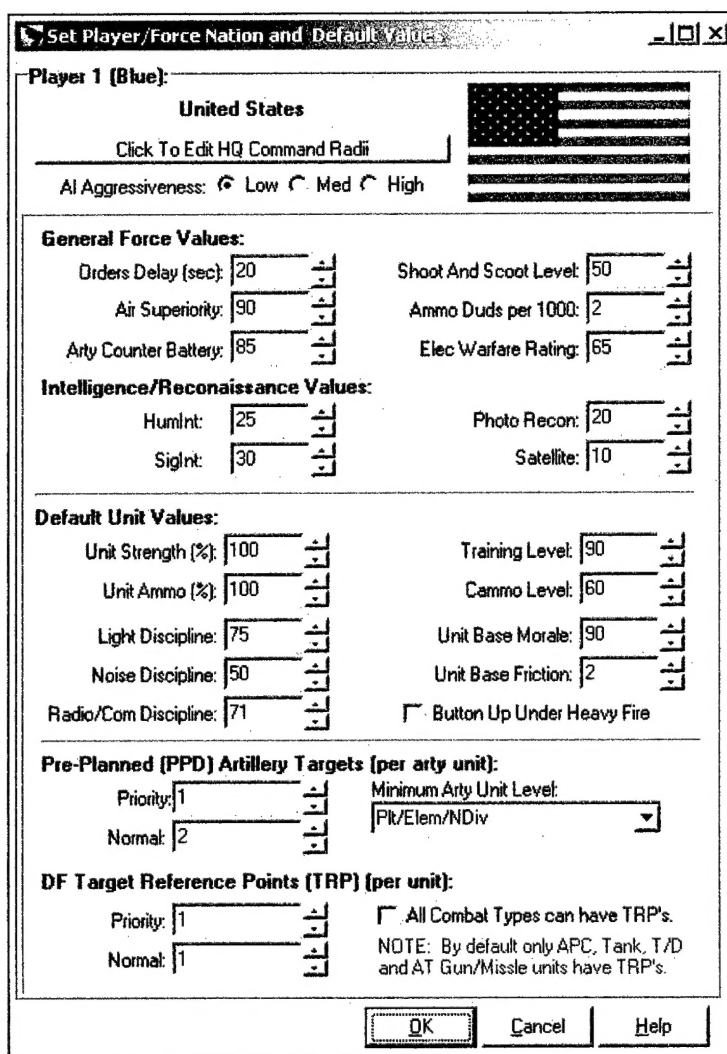
Figure 4: Force Values. The AI aggressiveness level can be set for each force. This level controls how the AI selects and implements strategies and tactics.

Figure 5: Unit SOP. The SOP orders control how the AI will select targets for individual units.

Figure 6: Reaction Orders. Reaction orders control how the AI will react to incoming fire for each unit.

```
Combat Phase Summary

Firing Unit: B  US Tank Company Loc: 3639
Target: Unknown Loc:1675
Range: 2438m (Est.) 58 % of max

Round: 1
Direct Hit
Projections:  Kill: 95;  Damage: 95;  Supm: 1
Impact Velocity: 857 mps
HE Penetration: 0mm
Base Kinetic Penetration: 975mm
Base Heat Penetration: 0mm
Final Penetration: 772mm
Excess Penetration: 665mm
Effective Armor Thickness: 106mm
Impact Surface: Hull Front
Spall: 0
Target: Damaged

Round: 2
Direct Hit
Projections:  Kill: 97;  Damage: 95;  Supm: 1
Impact Velocity: 857 mps
HE Penetration: 0mm
Base Kinetic Penetration: 975mm
Base Heat Penetration: 0mm
Final Penetration: 772mm
Excess Penetration: 665mm
Effective Armor Thickness: 106mm
Impact Surface: Hull Front
Spall: 0
Target: Damaged
```

Detail Level: ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ◉ 6   ☐ Sound On
Game Message Delay: 0 Secs ◄ ►   ☐ Animation On

Run Report   Close

Figure 7: Combat Reporting. Users can control the detail shown, subject to Fog of War.

8
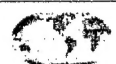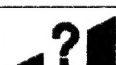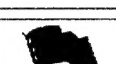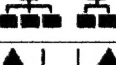
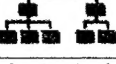**New Scenario Checklist** — □ ✕

✿☆	**Set Expert Level:** Current setting: Level 3 (Expert)
𝒊	**Set Scenario Information:** Title: Hold At All Costs Desc: 11 lines; Pic: 37thtank.bmp
🌐	**Set Map:** Hotot-en-Auge.map Size: 5.6 x 9.3 Km
☁📁	**Set Conditions/Data Tables:** Using standard conditions. Using standard weather.
➡🔲	**Set Initial Set-up:** Blue: United States; Defend; Red: CIS; Major Attack;
?◢	**Set Fog of War:** Blue Player: Level 1 Red Player: Level 1
🏴	**Set Blue Force Values:** Delay: 4; AirSup: 90; Intel: 21 Strength: 100; Supply: 100; Morale: 90
🏴	**Set Red Force Values:** Delay: 4; AirSup: 70; Intel: 16 Strength: 100; Supply: 90; Morale: 75
⬚	**Pick Blue Units:** Aprox. Size: 582 Personel; VP: 1990 Vehicles: 49 Aircraft: 0 Naval: 0
⬆⬆	**Pick Blue Flank Units:** Aprox. Size: 0 Personel; VP: 0 Vehicles: 0 Aircraft: 0 Naval: 0
👥	**Assign Blue Leaders:** 1 Leaders assigned
⬚	**Pick Red Units:** Aprox. Size: 215 Personel; VP: 1451 Vehicles: 41 Aircraft: 0 Naval: 0
⬆⬆	**Pick Red Flank Units:** Aprox. Size: 0 Personel; VP: 0 Vehicles: 0 Aircraft: 0 Naval: 0
👤	**Assign Red Leaders:** 0 Leaders assigned

Click 'Done' to place units on the map.   [Done]   Cancel

Figure 8: Create A New Scenario. This flexible checklist allows for easy scenario creation/modification.